Wright.—On lacustrine concretions from Grand Lake, N.S., by Prof. Honeyman, D.C L.—Illustrations of the fauna of the St. John, N.B. group, by G. F. Matthew.—On birds from Hudson's Bay, by Prof. Bell.—On a new classification of Crinoids, by Prof. E. J. Chapman. This classification is based essentially on the presence or absence of a canaliculated structure in the calyx and arm plates. Three leading divisions are thus recognised. In one, the plates are without internal canals; in the second, the arm plates are perforated internally; and in the third, a system of canals radiates from the base of the calyx to the extremities of the arms. The subdivisions have been worked out to bring readily under grasp the more salient or broadly distinctive features of all the better-known families and types; and as the common names of families embody very little indication of these features, an additional grouping into sections is adopted.—On the Lower Cretaceous rocks of British Columbia, by J. F. Whiteaves.—On the introduction and dissemination of some noxious insects, by Wm. Saunders.—On the geological history of the St. John (N.B.) river valley, by Prof. L. W. Bailly.—On recent discoveries in the life-history of *Botrydium granulatum*, a terrestrial Canadian alga, as illustrating phases of development in the lower forms of vegetation, by Prof. G. Lawson, Ph.D., LL.D.—On the Quebec group of rocks, by Dr. A. R. C. Selwyn.

The following officers were elected: President, J. W. Dawson, C.M.G., LL.D., F.R.S., Principal of McGill College, Montreal; Vice-President, Hon. P. J. O. Chauveau, LL.D.; Hon. Secretary, J. G. Bourinat, F.S.S., Ottawa; Hon. Treasurer, J. A. Grant, M.D., Ottawa.

ON SMELL

THE sense of smell is caused by the contact of certain substances with the terminal organs of the olfactory nerves, which are spread as a network over a mucous membrane lining the upper part of the nasal cavity. Each nerve consists of a number of small bundles, themselves capable of being split into extremely fine nerve fibres. There are spindle-shaped cells connected with these nerves, from which proceed two processes—one to the surface, provided with bundles of long hairlets; the other passes to the interior. It is these hairlets which are probably the proximate cause of smell.

Let us consider, first, by what are smells excited? The operation of smelling is performed by sniffing, that is, by a series of short inhalations of air, bearing with it the odorous body. The first question which suggests itself is: Is the substance which excites sensation a liquid, solid, or gas? It has been tried by Weber, to fill the nose with eau-de-Cologne and water, lying on the back for that purpose, and pouring the liquid into the nostrils by a funnel. No sensation is produced. I have myself tried the experiment, and can confirm his observation. There is an irritating feeling, but no smell. Of course, on washing out the nose, or blowing it, the characteristic smell is at once noticeable.

It is easy to prove that solid particles are not the cause of smell. If the air conveying the odour be filtered through a tube filled with cotton wool, and inserted into the nose, a smell is still discernible, although all solid particles must thereby be kept back. But it is a very remarkable circumstance that it is so, for one would not suspect such extremely non-volatile substances as copper, iron, silver, &c., to give off gas, if indeed the smell which they most certainly evolve when rubbed is due to the gas of the substance.

We must, therefore, conclude that the sense of smell is excited by gases only. It is of course necessary to include under the name gases the vapours of liquids or solids which have low vapour-tension, and which, in consequence, give off vapour at the ordinary temperature. It has been proved that this is the case even with mercury, the boiling point of which is over 300° Centigrade. We may consequently conclude that many other substances of which it is impossible to measure the vapour-tension at ordinary temperatures, owing to its extreme minuteness, also evolve gas, if only in very small quantities. But it is well known that all gases have not the power of exciting a sense of smell. Let us compare some gases which have smell, with some which have none, and endeavour to discover if those which have smell have any other property in common.

The following is a list of gases which have no smell:—Hydrogen, oxygen, nitrogen, water-gas, marsh-gas, olefiant-gas, carbon monoxide, hydrochloric acid, formic acid vapour, nitrous oxide, and ammonia. Those which possess smell are chlorine, bromine, iodine; the compounds of the first two with oxygen and water, the second three oxides of nitrogen (or perhaps it is right to say nitric peroxide, for the other lower oxides are changed into it when they come into contact with air); the vapours of phosphorus and sulphur; arsenic and antimony; sulphurous acid, carbonic acid, and almost all the volatile compounds of carbon, save those already mentioned; some compounds of selenium and tellurium; the compounds of chlorine, bromine, and iodine, with the above-named elements; and some metals.

In considering this list, I submit first, that the property of smell is peculiar to some elements and their compounds. Thus, chlorine, bromine, iodine, sulphur, selenium, and tellurium, which are volatile or give off vapour at ordinary temperatures, have a characteristic smell. We should expect their compounds to have a smell, and we find this to be the case. Second, those substances which have no smell, or produce simple irritation of the nostrils have all low molecular weight. Such is the case with hydrogen, the element of lowest specific gravity. Such also is the case with oxygen and nitrogen; but this as well as the absence of smell in water-vapour, may be ascribed to the constant presence of these gases in our atmosphere, and their necessary constant presence in our nostrils, so that we may be insensible to their smells because we are always inhaling them; but I think it probable that this is not so. Hydrochloric, hydrobromic, and hydriodic acids, and ammonia, have purely an irritating effect, and cannot be described as smells. When ammonia is pure and free from compounds containing carbon, it has no trace of smell. Nitrous oxide is also the lowest of the oxides of nitrogen, and as such has the lowest specific gravity. But it is when we turn to compounds of carbon that we are best able to draw general conclusions; for that element, *par excellence*, has the faculty of forming almost innumerable compounds, and series which resemble each other in properties, but differ in specific gravity. And here we are most struck with the fact that increase of molecular weight, *i.e.* increase of specific gravity in the form of gas, produces, to a certain point, smell. Let us examine the simplest series, viz. the marsh-gas or methane series, commonly called the paraffins. The first two of these have no smell. Ethane, indeed, which is fifteen times as heavy as hydrogen, begins to have a faint trace, but it is not till we arrive at butane, which is thirty times heavier than hydrogen, that a distinct sensation of smell is noticed. In the same manner, the olefine series, of which the first member is ethene, or olefiant gas, gains in smell with rise of molecular weight. Of course, the highest members of this series have no smell, for they are non-volatile, but this is the case with most carbon compounds of which the molecular weight is high.

A similar relation is noticeable among the alcohols. Methyl alcohol, in a state of purity, is smell-less; ethyl, or ordinary alcohol, when freed from ethers and as much as possible from water, has a faint smell, and the odour rapidly becomes marked as we rise in series, till the limit of volatility is reached, and we arrive at solids with such a low vapour tension that they give off no appreciable amount of vapour at the ordinary temperature. Again, with the acids, formic acid is smell-less, and produces a pure sensation of irritation. Acetic acid has a slight but charac, teristic smell; and the higher acids of the series, propionic butyric, valerianic acid, &c., gain in odour with increase in density in the form of gas. If we consider the nitrogenous compounds of carbon, we are led to the same conclusion. Prussic acid is not smelt by more than four persons out of every five; but the nitriles, which bear the same relation to prussic acid as the higher members of a series bear to the lower, have all very characteristic odours. Acetylene would appear to form an exception to this rule; but carefully purified acetylene has little odour, and it is surpassed by its higher homologues. We may therefore, I think, accept this as a principle—that the intensity of the smell rises with rise in molecular weight.

It is also noticeable that the *character* of a smell is a property of the element or group which enters into the body, producing the smell, and tends to make it generic. Thus we can characterise the compounds of chlorine and its oxides as chlorous; indeed we may group the three elements—chlorine, bromine, and iodine, together, and name the characteristic odour of them and their oxides haloid smells. Similarly, sulphur, selenium, and tellurium, in their compounds with hydrogen, have a generic smell; and likewise arsenic and antimony. The only oxide of nitrogen which is smelt is nitric peroxide, so that it is impossible to pronounce on a generic smell for this substance. It is, again,

easier to classify carbon compounds. The smell of the paraffins is generic; so is that of the alcohols, the acids, the nitriles, the amines with their irritation like that of ammonia, the bases of the pyridine series, the hydrocarbons of the benzene group, the higher hydrocarbons, such as naphthalene, anthracene, and phenanthrene. Give any one of these to a chemist familiar with the smell of any one of each series, and accustomed to use his sense of smell, and he will at once refer the body to its class.

The tendency of a rise in the series is to make the smell "heavier," less ethereal, and more characteristic. It also becomes more able to affect the olfactory nerves.

The rate at which smell travels is doubtless the rate at which the vapour which gives rise to it diffuses. Still it is impossible to test this experimentally. For the ease with which a smell is perceived varies with the molecular weight of the substance. Thus, if a piece of cotton wool be impregnated with ethyl alcohol, and placed in one end of a long tube, which is immediately corked, and a similar arrangement be adopted with amyl-alcohol, the fifth of the series of which the former is the second; although their specific gravities have the ratio of 23 to 44, and the ethyl-alcohol should diffuse $1\frac{2}{5}$ times as rapidly as amyl-alcohol, yet the smell of the latter will be perceived first, because a much smaller quantity produces the sensation.

It is possible, with practice, to make a fairly accurate analysis by means of the sense of smell. The method is, knowing the constituents of a mixture, to prepare one which has the same smell, measuring the proportions of the ingredients. The only precaution to be observed is that the smell of no member of the mixture be so overpowering as to mask those of the others. Thus I have analysed, or rather synthesised, a mixture of chloroform with ether, alcohol with ether, and these liquids with carbon disulphide, provided the latter be pure, to within 2 per cent.; but I failed with members of the pyridine series. Yet it was possible to detect the proportions of members of that series to each other; and it is not difficult, however extraordinary it may appear, to guess approximately the boiling-point of a mixture of members of a series, after some practice, purely by its smell.

So far as I know, no theory has been brought forward to account for the sense of smell; and I therefore venture to supply this want, premising that what follows is merely a tentative explanation, and as such will, I hope, not be too severely criticised.

There is a probability that our sense of smell is excited by vibrations of a lower period than those which give rise to the sense of light or heat. These vibrations are conveyed by gaseous molecules to the surface network of nerves in the nasal cavity. The difference of smells is caused by the rate and by the nature of such vibrations, just as difference in tone of musical sounds depends on the rate and on the nature of the vibration, the nature being influenced by the number and pitch of the harmonies.

Let us see what evidence can be adduced for the theory. Among the lightest substances which have smell are sulphuretted hydrogen and phosphoretted hydrogen, both of which are seventeen times as heavy as hydrogen itself. Prussic acid is fifteen times as heavy as hydrogen, and has a smell. But all persons are not able to perceive it. I have remarked an average of one in every five persons who are totally unable to detect its odour. Here we reach the lowest limit of molecular weight. *To produce the sensation of smell, then, a substance must have a molecular weight at least fifteen times that of hydrogen.* If we compare the hydrocarbons of the paraffin series, with each other, and similarly the olefine series, we notice that the lower members have no smell. The specific gravity of marsh-gas, CH_4, is 8; that of ethane, C_2H_6, 15; propane, C_3H_8, is twenty-two times as heavy as hydrogen, and here we first notice smell. Olefiant gas, C_2H_4, has the specific gravity 14, and has no smell; propene, C_3H_6, has a faint smell with a specific gravity of 21; and the higher members of the series increase in intensity of smell with increase in specific gravity. Hydrocyanic acid is smelt by most persons, but not by all. Its specific gravity is 15. The higher members of the series, called the nitriles, have all very characteristic smell. Formic acid vapour has the specific gravity 23, and has a purely pungent odour. Acetic acid, 30 times as heavy as hydrogen, has a faint smell when pure; propionic, butyric, and valerianic acids have strong smells. Methyl alcohol has no smell; its specific gravity is 16; ethyl alcohol, 23 times heavier than hydrogen, has a faint smell; and, as usual, the intensity, and if I may so term it, the flavour of the smell, increases as we rise in series.

These are the most typical instances of the carbon compounds, and they suffice, I think, to show the justice of the assertion that the intensity of smell increases with rise of molecular weight. The hypothesis of vibration satisfactorily explains this. The period of vibration of the lighter molecules is too rapid to affect our sense; there is a limit to this power; and just as some people have the power of hearing more acute sounds than others, so some senses are limited by a specific gravity of 15, and cannot smell prussic acid. Such people also have difficulty in perceiving the odours of bodies of slightly higher molecular weight than prussic acid.

Let us now inquire what is the probable rate of such vibrations. Mr. Johnston Stoney and Prof. Emerson Reynolds have made investigations of the ratio of the bright lines of some spectra, and have calculated their relations to each other. An analogy will make the nature of this relation more evident. When a note, say C, below the treble clef is sounded on a piano, not only the tone C is heard, but its octave C on the third space; also G above the line, C on the third leger line, E on the fourth, G on the sixth, B flat above the G, and other notes. These are called harmonics, or over-tones. Now if we knew these over-tones, it would be possible to refer them to their fundamental. So with light. The light evolved by incandescent gases consists of certain colours, which have each their own rate of vibration. Knowing these rates it is possible to calculate the rate of vibration of the fundamental. This has been done by Mr. Stoney (Royal Irish Academy, January 9, 1871) with hydrogen, with the following results:—

Wave-lengths,	*h*, 4102·37	tenth-seconds
,,	F. 4862·11	,,
,,	C. 6563·93	,,

These are the 32nd, 27th, and 20th harmonics of a fundamental whose wave-length is 0·1313 millimeters. The time of vibration is 4·4 fourteenth-seconds. It may be objected that these coincidences are not a proof. But Mr. Stoney and Prof Reynolds have measured the lines of the spectrum of chromyl chloride, and its 31 lines coincide with those calculated. The probability of the correctness of such a calculation approaches to almost absolute certainty. Now we have no means of recognising such fundamental vibrations, unless, indeed, the sense of smell is one means of receiving them. And it is this which appears to me probable; so probable, indeed, as to form a working theory.

But it is to radiant heat, I think, that we must look for indications of harmonics of the fundamental vibrations which are, according to this theory, the cause of smell. And a fresh proof may be drawn from the indications already seen. Prof. Tyndall has shown the power which odours have of absorbing heat-rays. There is no doubt that by refracting such heat-rays by means of a rock-salt prism, after they have passed through an atmosphere of odour, certain portions of the heat-spectrum show colder spaces, each corresponding to the particular rate of vibration which is absorbed by the vapour, through which the heat-rays have passed. By measuring the position of such gaps in the heat-spectrum, calculating the particular rate of vibration of the rays at such gaps, and referring them to their fundamental, we should arrive at the rate of vibration of the molecule which causes smell.

We may now inquire what it is which produces quality of smell. This, I think, can also be explained by the vibration theory, and depends on the harmonics of the vibration. Thus, the quality of tone of a violin differs from that of a flute by the different harmonics or overtones, peculiar to each instrument. I would ascribe to harmonics the quality of smell possessed by different substances. And it is to this that compounds of chlorine, phosphorus, &c., owe their peculiarity of odour. The odour of compounds resembles that of these elements to some extent; this may be accounted for by the similarity of overtones of compounds and their elements. Then we notice a similarity in quality of the odour of a compound of a series like the alcohols, and yet the quality grows flatter and heavier with increase in molecular weight.

Smell, then, may resemble sound in having its quality influenced by harmonics. And just as a piccolo has the same quality as a flute, although some of its harmonics are so high as to be beyond the range of the ear, so smells owe their quality to harmonics, which, if occurring alone, would be beyond the sense. It must be remembered that the harmonics are not heard sepa-

rately from the fundamental, unless special means be adopted to render them audible, but they add their vibrations to those of the fundamental.

When two sounds are heard simultaneously, they give a concord, or a discord, but each may be separately distinguished by the ear. Two colours, on the other hand, produce a single impression on the eye, and it is doubtful whether we can analyse them. But smell resembles sound and not light in this particular. For in a mixture of smells, it is possible, by practice, to distinguish each ingredient, and as I have shown, to match the sensation by a mixture.

With regard to the mechanism by which smell is conveyed to the nerve, all that can be said is pure speculation. But as it is supposed that the vibrations of sound are conveyed to the auditory nerve through the small cirrhi, or hairs which spring out of round cylindrical nerve-cells in the superficial layer of connective tissue of the epithelium of the internal ear, and that each is attuned to some particular note of vibrations, so it may be imagined that the hair-like processes connected with the spindle-shaped cells, themselves communicating with the nerve-fibres of the olfactory nerve, are the recipients of the vibrations causing smell. Although the rate of such vibrations is extremely rapid, no less indeed in the case of hydrogen than 4,400,000,000,000,000, or the four quadrillions, four trillionth part of a second, yet the wave-length is by no means so small, for it averages the 2-100th of an inch, a magnitude quite visible with the naked eye. And hydrogen has no smell; those bodies which have smell, and higher molecular weight, must necessarily have a slower period of vibration, and possibly greater wave-length.

It is doubtful whether there exists a lower limit to our sense of smell. The vapours of osmic acid, carbon tetrabromide, selenium, tellurium, and arsenicous and antimonious oxides are among the heaviest known, and they have a most distinct smell. There appears to be a limit in practice, however, owing to the non-volatility of substances of high molecular weight at such temperatures at which smell may be perceived. The intense perfume of flowers is to be ascribed to the terpenes, of which common turpentine is one, or to their products of oxidation, and these bodies all possess a molecular weight of 136, and the specific gravity 68, a specific gravity which appears to excite the olfactory nerve most powerfully.

I bring forward the theory adduced with great diffidence. The problem is to be solved, in my opinion, by a careful measurement of the "lines" in the spectrum of heat-rays, and the calculation of the fundamentals, which this theory supposes to be the cause of smell. Such measurements and calculations, even if they proved the theory untenable, would have great value for their own sake, and labour expended in this direction would not be lost. Whether successful or not, it would at least be a first assault on what old John Bunyan called "Nose-gate of the City of Mansoul."

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UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—A syndicate, on which Dr. Ferrers, Prof. Stokes, Prof. Balfour, Mr. Todhunter and Mr. Trotter may be taken to represent the interests of science, has been appointed to frame regulations for the new degrees of Doctor of Science and of Letters. Candidates for these degrees are required by the new statutes to have made some original contribution to the advancement of science or of learning.

In the last Mathematical Tripos under the old regulations (January, 1882) the full marks were 27,150, and the average marks of the first ten wranglers were 6712, of the last ten 2890; first ten senior optimes average 2093; first ten junior optimes, 818. Out of 1407 marks given to the problems in the first three days, the first ten wranglers gained an average of 255; out of 8161 given to the problems in the last five days, the same ten averaged 849.

An important report by Mr. G. H. Darwin, who was the additional examiner in the same tripos, criticises severely the style in which the work of many men was done. Not a few sent up answers in atrocious handwriting, and omitted to define many symbols employed. The subjects which exhibited the average weakness of grasp most flagrantly was thermodynamics. A great many men had read something of it, but very few really understood what they attempted to explain. "Extraordinary muddle and confusion" was sent up in answer to a question on the absolute scale of temperature. On another question, while the very elements of the subject were unknown to those who answered, the same men reproduced faultlessly the algebraical calculation of the thermodynamic function for a perfect gas. Mr. Darwin strongly recommends such changes in the style of questions as that half intelligence may be more stringently treated, and men induced to read less and master more, and to gain a comprehension of physical principles.

The affiliation of University College, Nottingham, to Cambridge University has been formally recommended, so soon as the constitution of its governing body has been altered so as to admit a representative of the University. Scientific subjects have full recognition in the college course of study, by which exemption from one year's residence at Cambridge may be obtained, provided the student takes a degree in honours.

When Statute B comes into operation, the present Board of Natural Science Studies is to be replaced by two Boards—that of Physical and Chemical Studies and that of Biological and Geological Studies. These Boards will include, besides the Professors and Readers belonging to these studies, the Tripos Examiners of two years in the respective subjects belonging to the Boards, and three members of the Senate elected to serve for three years.

The second part of the Natural Sciences Tripos this year has no name in the first class, a result probably attributable to the transition state of the Tripos. Next June a better result may be anticipated, unless students with one consent let alone the more advanced parts of all the subjects. If this is the consequence of the recent changes, it will be much to be regretted.

OXFORD.—The term that has just ended has been chiefly remarkable for the fact that the new Statutes have come into operation in default of obstruction in Parliament. Already at several of the colleges, tutors and lecturers who have vacated their fellowships by marriage, have been re-elected "official Fellows;" and others who hold fellowships under the old ordinances have transferred themselves to the new official class.

But little legislation has been effected in Convocation: the only proposal of the Hebdomadal Council which provoked opposition was that to raise the University dues from five shillings to seven and sixpence a term, and to double the fee for Responsions (smalls), making it 2*l.* instead of 1*l.* Both proposals were carried on a division. The new Statute on Private Halls—containing provisions for bringing the master and students of such halls under the direct supervision of the University—was passed after being amended in Congregation. A Statute postponing the date of the University Examinations was also passed; so that in future the final honour schools will not commence before the last week of term.

During Michaelmas term, there will be offered two scholarships for proficiency in Natural Science. At Balliol there will be an election to a scholarship on the foundation of Miss Hannah Brakenbury, "for the encouragement of the study of Natural Science," worth 80*l.* a year (55*l.* and tuition free), tenable during residence for four years: open to all such candidates as shall not have exceeded eight terms from matriculation. This examination will begin on Thursday, November 16, at ten o'clock. Papers will be set in the following subjects:—(1) Mechanical Philosophy and Physics; (2) Chemistry; (3) Biology. But candidates will not be expected to offer themselves in more than two of these. There will be a Practical Examination in one or more of the above subjects, if the Examiners think it expedient. There will also be an optional paper in Mathematics; and the literary qualifications of the candidates will be tested by an English essay, or by a paper of general questions.

At Trinity College one Millard and Combe Scholarship, of the annual value of 80*l.*, without limit of age, will be awarded in October next for proficiency in Natural Science if any Candidate of sufficient merit offers himself. The Scholarship is tenable in the first instance for two years, and will be prolonged for two years more, if the President and Fellows are satisfied with the industry and good conduct of the scholar. For special reasons it may be prolonged for a fifth year. The subjects of examination will be Chemistry and Physics. Candidates may also offer Mathematics, if they wish to do so and give notice a week before the examination. Special weight will be attached to excellence in one or two subjects, rather than to a less thorough knowledge of all. Candidates will also have an opportunity of doing one Classical paper. The scholar elected will not necessarily be required to commence residence